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(54) FLYWHEEL-DRIVEN IMPACTING TOOL

(71) We, JAMES EVERETT SMITH of 217 Meadowlook Way, Boulder, Colorado 80302, United States of America, and JAMES DYKSTRA CUNNINGHAM of 2100 Topaz, Boulder, Colorado, 80302, United States of America, both citizens of the United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to impacting tools and more particularly, but not exclusively, to tools for example for driving small nails and staples, loosening and tightening nuts, and setting deformable fasteners such as small brass and copper rivets.

According to the present invention, there is provided an impact tool for applying impact forces to an impact-receiving object, comprising a ram mounted for movement along a drive path toward and away from the impact-receiving object, a first flywheel located to one side of the ram, means for rotating said flywheel, means supporting at least one of the ram and flywheel for movement relative to the other between a disengaged position and an engaged position in which the flywheel is in driving engagement with the ram to drive flywheels such that the ram is frictionally engaged between the rotating flywheels and is driven by the flywheels along the drive path.

Still further according to the present invention, there is provided an impact tool comprising a housing having a forwardly-extending nozzle with an opening at the front end thereof and communicating with a flywheel cavity therebehind, ram means mounted within the housing for sliding movement between a retracted position within the flywheel cavity and an extended position projecting into the nozzle, a substantially identical pair of flywheels journalled for rotation adjacent the ram means on opposite sides thereof about parallel axes normal to its direction of travel, drive means connected to the flywheels and operative to rotate the flywheels in opposite directions at substantially the same speed, pivotal mounting means journalling at least one of the flywheels for arcuate movement in a direction to change the spacing between the pair of flywheels, the flywheels defining a clutch operative upon actuation to frictionally grip the ram means therebetween and propel same forwardly until is reaches a point where it is no longer in driving contact therewith, clutch actuating means connected to the mounting

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SPECIFICATION NO 1487098

The following amendments were allowed under Section 29 on 5 January 1979

Page 1, *delete* lines 14 to 19 *insert* impacting tools.

Page 7, *after* line 43 *insert* Although the tool particularly described herein is primarily intended for driving large nails and workpieces such as herein specified which required high energy, a tool in accordance with the invention may be constructed for driving small nails and staples, for loosening and tightening nuts, and for setting small deformable fasteners such as small brass and copper rivets.

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(54) FLYWHEEL-DRIVEN IMPACTING TOOL

(71) We, JAMES EVERETT SMITH of 217 Meadowlook Way, Boulder, Colorado 80302, United States of America, and JAMES DYKSTRA CUNNINGHAM of 2100 Topaz, Boulder, Colorado, 80302, United States of America, both citizens of the United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to impacting tools and more particularly, but not exclusively, to tools for example for driving small nails and staples, loosening and tightening nuts, and setting deformable fasteners such as small brass and copper rivets.

According to the present invention, there is provided an impact tool for applying impact forces to an impact-receiving object, comprising a ram mounted for movement along a drive path toward and away from the impact-receiving object, a first flywheel located to one side of the ram, means for rotating said flywheel, means supporting at least one of the ram and flywheel for movement relative to the other between a disengaged position and an engaged position in which the flywheel is in driving engagement with the ram to drive the ram along the drive path in a direction toward said impact-receiving object, and rotary means located on the opposite side of the ram to the flywheel, said rotary means being in rolling engagement with the ram to support the ram during axial movement along the drive path.

Further according to the present invention, there is provided an impact tool for applying impact forces to an impact-receiving object, comprising a ram mounted for movement along a predetermined drive path toward and away from the object, a pair of counter-rotating flywheels located on opposite sides of the drive path, and means for moving one of the flywheels towards the other of the flywheels such that the ram is frictionally engaged between the rotating flywheels and is driven by the flywheels along the drive path.

Still further according to the present invention, there is provided an impact tool comprising a housing having a forwardly-extending nozzle with an opening at the front end thereof and communicating with a flywheel cavity therebehind, ram means mounted within the housing for sliding movement between a retracted position within the flywheel cavity and an extended position projecting into the nozzle, a substantially identical pair of flywheels journalled for rotation adjacent the ram means on opposite sides thereof about parallel axes normal to its direction of travel, drive means connected to the flywheels and operative to rotate the flywheels in opposite directions at substantially the same speed, pivotal mounting means journalling at least one of the flywheels for arcuate movement in a direction to change the spacing between the pair of flywheels, the flywheels defining a clutch operative upon actuation to frictionally grip the ram means therebetween and propel same forwardly until is reaches a point where it is no longer in driving contact therewith, clutch actuating means connected to the mounting means and operative to actuate the clutch, clutch release means, associated with the mounting means, operative to reopen the space between the flywheels immediately upon their becoming drivingly disengaged from the ram means by deactuation of the clutch actuating means, and ram return means connected to the ram means and operative to return same to its retracted position following actuation thereof, into extended position and actuation of the clutch release means.

Figure 1 is a schematic representation of control in accordance with the present invention,

Figure 2 is a perspective view of the tool

as seen from a vantage point above and to the left of its rear end;

Figure 3 is a top plan view of the tool to an enlarged scale, portions having been broken away to both conserve space and better reveal the interior construction;

Figure 4 is a transverse section taken along line 4—4 of Figure 3 to a further enlarged scale;

Figure 5 is a longitudinal section in the same scale as Figure 4 taken along line 5—5 of Figure 3;

Figure 6 is a section taken along line 6—6 of Figure 5 and to the same scale as the latter Figure, portions again having been broken away to conserve space;

Figure 7 is a fragmentary section similar to Figure 6, but showing a ram of the tool advanced into its fully-extended position;

Figure 8 is a fragmentary section taken along line 8—8 of Figure 3 to an even further enlarged scale;

Figure 9 is a fragmentary perspective view to the same scale as Figure 8 and with portions broken away and shown in section to better reveal the interior construction;

Figure 10 is a fragmentary section similar to Figure 5 and to the same scale as the latter showing the trigger actuated, but the nosepiece still extended;

Figure 11 is a fragmentary section like Figure 10 except that the nosepiece is shown in retracted position; and,

Figure 12 is a schematic of a representative motor speed control circuit,

Before turning to a detailed description of a nail-driving embodiment of the present invention that has been broadly designated by reference number 10, reference will be made to the schematic view of Figure 1.

It can be demonstrated experimentally with a simple arbor press that a 16 penny nail which is 3.25 inches long requires a peak force of about 1000 lbs. to drive it all the way up to the point where its head is flush with the surface of a piece of medium hard timber.

The tool shown in Figure 1 can be used to drive such a nail into timber in just a few milliseconds and uses a flywheel as energy storage means. The tool is a hand-held tool and has two functionally identical flywheels 14 and 16 rotating in opposite directions about parallel axes at the same speed in order to cancel out the procession moments that are most unwelcome in a hand-held tool.

A ram element 12 is pinched between the pair of counter-rotating flywheels 14 and 16 which drive same forwardly without slipping to enable the entire work stroke of the ram to be completed in a few milliseconds.

The driving connection between the flywheels and the ram is a frictional connection which requires no synchronous engagement as would a rack and pinion and the like. The flywheels form a clutch, and the flywheels while spinning at the required speed are brought into substantially instantaneous driving engagement with the ram.

Both flywheels may be moved toward and away from one another to engage and disengage the ram or, alternatively, only one need move relative to the other, the movable one engaging the ram and pushing it sideways against the fixed one, of the two, the latter approach is preferred for the reason that if the ram floats between two relatively movable flywheels, one will reach it ahead of the other each actuation rather than simultaneously. As this happens one flywheel of the pair will have to yield to the other in which the overbalancing force is present. It can be shown that these ram engaging forces are of the order of three times the force necessary to drive the nail, i.e. 3000 lbs. as compared with 1000 lbs; therefore, a yieldable flywheel mounting system becomes a most difficult mechanism to properly design and engineer. Furthermore, one is never sure what path the ram will follow on its forward excursion or work stroke as it may be on either side of its guideway depending upon which of the two flywheels has taken precedence over the other on the particular actuation. For the reasons above noted, one flywheel is mounted for rotation about a fixed spin axis and the other flywheel is movable.

While it is certainly possible to shift the movable flywheel toward the fixed one along a line perpendicular to the direction of ram travel into its extended position, developing a ram-engaging force nearly three times the maximum force developed in the ram becomes a serious problem. It has been found, however, that ram-gripping forces of sufficient magnitude can easily be developed by swinging the movable flywheel arcuately into engagement about an axis of pivotal movement lying to the rear of its spin axis. As the surface of the movable flywheel engages the adjacent ram surface and forces the ram over against the surface of the fixed flywheel, its direction of rotation is such as to roll it rearwardly thereby increasing the pressure it exerts against the ram. Such flywheel action upon engagement with the opposite ram surfaces instantly and easily develops the requisite ram-gripping forces even though they exceed the maximum driving force developed in the ram by a three-fold factor.

The theoretical arcuate excursion of the movable flywheel's spin axis is back into a plane passing through its axis of pivotal movement that is perpendicular to the

direction of ram travel into its extended position. Once the spin axis passes rearwardly beyond this plane, however, the clutch loosens its grip on the ram and the driving connection is lost. However, to enable wear between the various parts to be taken up the spin axis of the arcuately movable flywheel is stopped short of this position.

If θ is the acute angle at the intersection of a plane defined by the spin axis of the arcuately-movable flywheel and its axis of pivotal movement and a second plane perpendicular to the direction of movement of the ram 12 into its extended position and K_f is the coefficient of friction between the ram and the flywheel, it can be shown that if $K_f \geqslant \tan\theta$, the flywheels will not slip once engaged with the ram. It is quite simple to select the angle θ or the coefficient of friction K_f so that the foregoing relationship is present.

The flywheels are cylindrical and the engaged faces of the ram are planar so that they mate in tangential relation making straight-line contact with one another along a line parallel to the spin axis. Other complementary surfaces are unsatisfactory for the reason that points thereon at different distances from the spin axis will, of necessity have different peripheral velocities and slippage is bound to result.

A few other points are worthy of specific mention before proceeding with a detailed description of the nail-driving embodiment of the impact tool. Motor size is a consideration and it depends upon the required duty cycle. The average power required to drive a 16 penny nail fully into a workpiece would be approximately 75 hp. Since energy is stored in the flywheels, the actual motor size required to drive them may vary from 0—75 hp depending upon the required duty cycle. If a duty cycle of 5 actuation/sec. is chosen, the required motor would be about 1.125 hp. In other words, a 1.125 hp motor could maintain flywheel speed even using five actuations per second. Obviously, this is an excessive duty cycle from a practical standpoint and a small fractional horsepower electric motor would be entirely adequate. Furthermore, the amount of energy dissipated per actuation is such that battery power would be quite adequate to power the motors in light to medium duty applications over moderate time spans of a few hours or so.

Excessive ram energy can be a problem and provision needs to be made for controlling same. The first of two provisions for doing so is by means of a speed control 18 for the motor or motors driving the flywheels such as that shown schematically in Figure 12 and which is merely representative of one such speed control that could be used. The various positions of the control knob 20 can be indexed to positions on the scale 22 (Figure 2) that are calibrated directly in nail sizes, for example.

Since enough energy must be imparted to the ram to ensure completion of the work assigned thereto, a slight excess is ordinarily employed. To avoid damaging the workpiece due to the presence of this excess energy, however, means are preferably provided for dissipating some before it can cause the ram to dent, gouge, puncture, scar or otherwise damage the workpiece. An energy-absorbing cushion 24 is placed in the nosepiece 26 on the front end of the nozzle 28 of the case effective to receive and absorb some of the excess energy left in the ram as it nears completion of its work stroke. If, however, the ram is still being positively driven by the flywheels, such a cushion is inadequate. Accordingly, the length of the ram is preferably such in relation to the location of the flywheels behind the nosepiece that the ram has moved out of positive driven engagement therewith prior to its completing its work stroke or striking the cushion 24 as shown most clearly in Figure 7. This means, of course, that the cushion is no longer required to absorb the direct energy being supplied to the ram by the flywheels at the end of its stroke, but only that energy left over due to its mass and velocity. Obviously, the lighter the ram, the less residual energy it has at the end of its stroke, all other factors being equal.

At the instant the ram moves forward beyond the flywheels and becomes disengaged therefrom, at least insofar as a driving connection therebetween is concerned, the gap between the flywheels is re-opened to allow the ram to complete its cycle of movement by passing back therebetween under the influence of tension spring 50 connected thereto. In the particular form shown, the clutch actuating means comprises the nosepiece 26 which is mounted for retractable movement relative to the nozzle 28, and a rigid link 32 which operative connects the nosepiece to the pivoted frame 34 journalling the movable flywheel 16 for arcuate movement. As the nosepiece moves rearwardly into retracted position upon being pressed against a workpiece W in the manner shown in Figure 7, link 32 acts upon the pivoted frame 34 to swing the movable flywheel rearwardly into engaged ram-driving relation. Once engaged, the ram cannot be released until it leaves the flywheels even if it were possible to return the nosepiece to its extended position during the few millisconds it takes to complete the power stroke. Once the ram has, in fact, moved

out of driving engagement therewith, the gap between the flywheels is re-opened; in other words, the clutch format by the flywheels is disengaged. This is accomplished automatically by a clutch release means connected to normally bias the pivotal frame 34 in a direction to open the gap between the flywheels. In the particular form shown, the clutch release means takes the form of a compression spring 36 normally biasing the retractable nosepiece 26 into extended position. Thus, before this particular clutch release means can function, the biasing force it exerts on the nosepiece must exceed the opposing retracting force exerted thereon by the workpiece W. As a practical matter, as soon as the ram has completed its work stroke, the operator will usually remove the nosepiece from engagement with the workpiece thus permitting the clutch release means to open the gap between the flywheels so spring 30 can retract the ram therebetween.

Turning next to Figure 2 where the nail-driving embodiment 10 of the tool has been shown in perspective, reference numeral 40 has been selected to designate the case or housing in its entirety, nozzle 28 forming a part thereof. Immediately behind the nozzle is an enlargement which will henceforth be referred to as the "flywheel cavity" 42. Within this cavity is housed the drive means in the form of a pair of identical electric motors 44, the movable mounting 34 for one of them, and the fixed mounting 46 for the other. Extending on rearwardly of the flywheel cavity as an integral part of the housing aligned longitudinally with the nozzle is the upper limb 48 of the handle 50. Limb 48 is hollow and adapted to receive the ram 12 in its retracted position as shown in Figures 5 and 6. In the particular form shown, speed selector switch 20 of the speed control 18 along with the scale 22 calibrated in nail sizes or the like are provided on the rearwardly-forcing wall 52 on the back of handle 50. The handle 50, as a whole, has the usual C-shaped configuration commonly associated with many electrically-driven hand tools. The handle 50 also carries the trigger 54 and the line cord 56 to the source of electrical power in the event a self-contained power source is not used.

As illustrated, the case has a removable cover plate 58 which provides access to the interior thereof and, in addition, it is shown die cast in two halves which are bolted together. The nail gun form of the tool, of course, requires an opening 60 (Figures 7, 8 and 9) into which the nails or other fasteners 62 are fed into the path of the advancing ram 12. A magazine 64 of conventional construction has been shown feeding in a commercially-available belt of nails into opening 60 in the side of the nozzle.

Figures 3—7, inclusive, to which reference will now be made, show the interior construction of the tool most clearly. Resting in the bottom of flywheel cavity 42 is a fixed endplate 66 which carries a bearing 68 journalling the shaft 70F of fixed motor 44F. An upstanding partition wall 72 divides the flywheel cavity into two motor compartments 74 and 76. A horizontal wall 78 formed integral with the partition wall 72 separates the motor compartments 74 and 76 from the flywheel compartment 80. The horizontal wall is shown supported on ledges 82 on the inside of the flywheel cavity. Additional shaft bearings 68 are mounted in fixed position in one half of the flywheel compartment, one being recessed in the top of the horizontal wall while the other is received into the lid. Fixed flywheel 14 is mounted on the portion of motor shaft 70F projecting from motor compartment 74 up into the flywheel compartment. Thus, the fixed motor 44F and its flywheel 14 are housed in one side of the flywheel cavity alongside ram 12.

In the other side of the flywheel cavity, is mounted movable motor 44M, its shaft 70M and movable flywheel 16. Fixed endplate 66 is replaced by movable endplate 84 that carries bearing 68 journalling the lower end of shaft 70M of the movable motor 44M. This endplate together with vertically-spaced parallel arms 86 cooperate to define the pivoted mounting means 34 that carries motor 44M and its flywheel for pivotal movement in a direction to vary the width of the gap so as to engage and form a driving connection with the ram. The lower end of pin 88 is non-rotatably fastened in an integrally-formed foot 90 provided on the underside of the movable endplate 88 which skids back and forth on the bottom of the housing. The housing is shown provided with an enlargement 92 to accommodate the pivot pin, the upper end of which is rotatably mounted in a socket 94 in the coverplate 58. As shown, arms 86 are joined together by a web 96 to define a unitary structure which is non-rotatably fastened to the pivot pin 88. These arms and movable endplate 84 each carry bearings 68 journalling the shaft 70 of motor 44M. An oversize aperture 98 in the horizontal wall 78 accommodates the shaft 70 of the movable motor and permits the entire pivoted mount 34 therefore to swing arcuately relative thereto between its engaged and disengaged positions. Note in Figures 1 and 3 that the axis of pivotal movement defined by the pivot pin 88 is

located to the rear of the spin axis of the movable flywheel defined by movable motor shaft 70. Thus, even when fully engaged as shown in Figure 7, the spin axis still lies well ahead of a plane passing through the axis of pivotal movement of the mount that is perpendicular to the path followed by the ram during its excursion into extended position or work stroke. As will be seen presently, the ram is loosely fitted for longitudinal slidable movement in the opposed track-forming grooves 100 of the clutch actuating means 32 so that it can move aside the fraction of an inch required to bring it into engagement with the fixed flywheel. Once thus engaged, however, the ram follows a straight-line path determined by the shoulders 102 of the track-forming grooves or guideway remote from the movable flywheel that is urging the latter thereagainst. It is for this reason that the angle θ in Figure 1 and the nornal plane have been defined in terms of the forward excursion of the ram. The return stroke of the ram, while confined to the guideway, need not follow a straight line and, in fact, can be slightly canted therein.

Directing the attention next to Figures 3—11, inclusive, it can be seen that a pair of rearwardly-extending parallel arms 104 are attached to the rear face of the nosepiece 26 and mount same within the nozzle for limited reciprocating movement between its normally extended position and a retracted one. These arms perform a dual function, the first of which is that of guiding the ram between its extended and retracted position due to the track-forming grooves 100 formed in the opposed surfaces thereof. Secondly, it is these same arms that are operatively linked to the arms 86 of the pivoted mount 34 and thus cooperates with the nosepiece to define the clutch actuating means 32.

These arms, while forming the guideway for the ram, are, in themselves, guided for limited reciprocating slidable movement in opposed grooves 106 formed on the underside of the lid 58 to the housing and bottom walls of the nozzle 28 and upper handle limb 48 into which they telescope. In contrast to the ram 12, arms 104 are closely confined within the grooves 106 in the housing so that its movement is restricted to essentially straightline motion.

As revealed most clearly in Figures 10 and 11, a fixed limit stop 108 provided on the underside of lid 58 engages a movable stop 110 carried by the upper arm 104 to limit the forward excursion of the clutch-actuating means 32. The rearward movement of the latter is stopped when the nosepiece 26 engages the front end of the nozzle. One or more compression springs 36 positioned between the opposed faces of the nozzle and nosepiece normally bias the latter into extended position. These springs constitute a clutch release mechanism automatically operative to disengage the clutch in a manner to be explained in detail presently as soon as the clutch actuating means 32 is deactuated by permitting the nosepiece to return to its normally-extended position.

Now, in Figures 3—7 it can be seen that the ends of arms 86 of the pivoted mount 34 remote from pivot pin 88 are provided with vertically-aligned ears 112 that are received in notches 114 formed in the boss 116 provided on one side of arms 104. The connection thus formed between the clutch actuating means 32 consisting of the nosepiece 26 and arms 104 operatively links the latter to the clutch means consisting of the flywheels and pivoted mount 34. As the clutch actuating means 32 is actuated by pressing the nosepiece against a workpiece with sufficient force to overcome the bias exerted thereon by springs 36 and retract same, it will swing the mounting means 34 rearward arcuately to close the gap separating the flywheels thus engaging the clutch by gripping the ram therebetween. As previously noted, once engaged, the clutch wil remain so until the ram clears the flywheels as shown in Figure 7. When this happens, the clutch can be disengaged and it will do so automatically under the influence of the clutch release springs 36 provided the clutch actuating means 32 has been deactuated. In other words, so long as the nosepiece remains pressed against workpiece, ram retraction spring 30 will be pulling it back into contact with the flywheels, but they will not spread apart to allow it to pass therebetween. As soon as the pressure on the nosepiece is relieved to a point when the bias on the latter by clutch release springs 36 can extend it, the gap between the flywheels will reopen and the ram can complete its return stroke.

The flywheel engaging surfaces of the ram will both be seen to include friction pads 188 formed from some tough abrasion resistant material having a reasonably high coefficient of friction when placed in contact with a metal flywheel such as, for example, ordinary brake lining material. As ram retraction spring 50 biases the ram rearwardly, it strikes limit stop 120 shown in Figure 5.

The front end of the ram is shaped to define a nose 122 bordered both top and bottom by forwardly-facing shoulders 124 best seen in Figures 5, 8 and 9. The nose 122 passes through an aperture 126 sized to receive same in the nosepiece while the shoulders engage the shock-absorbing cushion 24 bordering the latter. Whatever, energy is left in the ram at the completion

of its workstroke is, hopefully, dissipated in this cushion, otherwise, the nose of the ram will impact against the workpiece itself.

Particular reference will next be had to Figures 5, 6, 7, 11 and 12 for a detailed description of the trigger 54 and a safety interlock between the latter and the clutch actuating means 32. Trigger 54 is pivotally mounted within the opening in the handle in the usual manner and is normally biased forwardly by spring 128. As the trigger is manually actuated into retracted position it closes the normally-open on/off switch 130 in the motor speed control circuit 18, the latter having been shown located in the lower limb 132 of the handle.

A vertically disposed T-shaped slot 134 is formed integral with web 136 on the inside of the handle above the trigger. Mounted within this slot for limited vertically slidable movement is a limit stop 138 operatively connected to the trigger by link 140. As the trigger 54 is retracted into its actuated position, it acts through connecting link 140 to raise the stop 138 and move its forwardly-projecting abutment 142 from behind the lower arm 104, thus allowing the clutch actuating means 32 to move rearwardly so as to engage the clutch. With the trigger released, abutment 142 blocks the retraction of the nosepiece 26 which, as previously noted, is necessary to engage the clutch. Thus, if the tool is running and dropped on its nose by the operator, he will, of necessity, let go of the trigger thus interpositioning the abutment 142 and prevented the clutch from engaging which, otherwise, would have actuated the ram to discharge a nail.

As shown in Figures 6, 7, 8 and 9, the magazine 64 and includes upper and lower parallelogram-shaped plates 144 and 146 connected along the front edge by a wall 148 that cooperates therewith to produce rearwardly-opening channel. Tracks 150 spaced to receive the shanks of the nails 62 therebetween and hold same for slidable movement in alignment with the nose 122 of the ram are located just inside the opening in the rear edge. The nail heads butt up against this track and are advanced into position to be driven by a follower 152 which is pulled by a coiled tension spring 154.

The nails themselves are joined together to form a belt by paper tapes 156 in the conventional way as shown. The lead nail of the chain abuts a stop 158 inside the nozzle across from opening 60 that holds it in alignment with the nose of the ram. The second nail, on the other hand, is still held back by the track 150. Therefore, as the ram advances, it strips the lead nail from the belt and drives it on into the workpiece: whereupon, the follower moves the next nail into position to be driven as soon as the clutch actuating means is deactuated, the clutch release means opens the clutch, and the ram retraction spring pulls it back to clear the nozzle. To reload the magazine, the follower is pulled all the way out in much the same way a stapler is loaded. Since no novelty is predicated upon the magazine *per se*, a detailed description of its structural features would serve no useful purpose. The same is true of the motor speed control circuit of Figure 12 which has no details identified other than those components which have mechanical significance in the tool itself.

It should be noted that while the tool shown is specifically constructed for driving nail-like fasteners, it is by no means so limited and the ram can impact directly upon an external workpiece in manner of a stamp, punch or chisel just as well as through the medium of a fastener; also the tool can be used for driving staples or rivets. It can easily be seen that a tool having the following parameters is practical and, in addition, will perform adequately in any of the previously mentioned applications:

Flywheel Diameter	3"
Flywheel Speed	7000 r.p.m.
Ram Speed	1000 in./sec.
Motor Horsepower	1.125
Total Instrument Wt.	10 lb.

The handheld impact tool particularly described, is capable of developing the 75 horsepower or so required to drive a 3-1/4" nail during a brief interval lasting a few thousandths of a second. In fact, a small fractional horsepower electric motor will be entirely adequate to answer the power requirements of a duty cycle calling for about one actuation per second.

A pair of substantially identical counterrotating flywheels, store the necessary energy and, in addition, when properly matched and oriented relative to one another, co-operate to cancel out the bothersome precession moments inherent in high speed rotating system having flywheels. These same flywheels, when one is moved relative to the other so as to engage a friction ram positioned therebetween, coact to define an efficient high speed power transfer mechanism capable of imparting a considerable driving force to the ram in matter of a few milliseconds. The clutch thus produced requires no synchronous engagement and, when properly constructed, is free of slippage.

The incorporation of mechanical interlocks which require that the nose of

the tool to be held firmly against the workpiece while the trigger is actuated to engage the clutch make the tool safe to operate while, at the same time, disabling it from discharging a fastener should it be dropped accidently. The motor speed control, provides the operator with the means by which he can reduce the ram energy to an appropriate level commensurate with the job being performed thus preventing damage to the workpiece.

Ordinary household current is entirely adequate as a power source and, in fact, the power demands are such that they could easily be supplied by batteries or a small self-contained generator, especially in the case of a low demand duty cycle. The problem becomes one of the time involved to get the flywheel drive motors up to speed rather than the dissipation of energy during the drive cycle which is minimal even with a small fractional horsepower motor.

The tool, when constructed for use as a nailer, is readily adapted to accept commercially-available strips or belts of nails without modification. The same is true of other types of fasteners such as rivets and the like when similarly packaged.

The matched pair of counterrotating flywheels serve as the energy transfer medium by means of which the latent energy stored therein is imparted almost instantaneously to the ram. The ram is operated by a self-locking virtually slipless high power friction clutch that eliminates the need for synchronous engagement inherent in toothed clutches.

The tool is lightweight and of rugged construction, relatively inexpensive, versatile, safe, dependable, easy to operate, simple to service, powerful, efficient, and of attractive appearance.

WHAT WE CLAIM IS:—

1. An impact tool for applying impact forces to an impact-receiving object, comprising a ram mounted for movement along a drive path toward and away from the impact-receiving object, a first flywheel located to one side of the ram, means for rotating said flywheel, means supporting at least one of the ram and flywheel for movement relative to the other between a disengaged position and an engaged position in which the flywheel is in driving engagement with the ram to drive the ram along the drive path in a direction toward said impact-receiving object, and rotary means located on the opposite side of the ram to the flywheel, said rotary means being in rolling engagement with the ram to support the ram during axial movement along the drive path.

2. A tool according to claim 1, wherein the rotary means comprises a second flywheel.

3. A tool according to claim 1 or claim 2, wherein the first flywheel is mounted for movement into and out of driving engagement with the ram.

4. A tool according to claim 3, wherein the support means mounting the first flywheel for movement into and out of driving engagement with the ram is pivotal about an axis parallel to the rotational axis of the first flywheel.

5. A tool according to claim 4, wherein the pivotal axis of the support means is located behind the rotational axis of the first flywheel in the direction of movement of the ram toward the impact-receiving object.

6. A tool according to any one of claims 1 to 5, wherein the rotary means is rotatable about a fixed axis parallel to the axis of rotation of the first flywheel.

7. A tool according to any one of claims 1 to 6, wherein said object is a fastener and the tool further comprises a magazine for the fasteners, and means for feeding individual fasteners from the magazine onto the drive path to be engaged by the ram.

8. A tool according to claim 2 or claim 2 and any one of claims 3 to 7 comprising separate motors for driving the two flywheels, and means for controlling the speed of the motors.

9. An impact tool for applying impact forces to an impact-receiving object, comprising a ram mounted for movement along a predetermined drive path toward and away from the object, a pair of counter-rotating flywheels located on opposite sides of the drive path, and means for moving one of the flywheels towards the other of the flywheels such that the ram is frictionally engaged between the rotating flywheels and is driven by the flywheels along the drive path.

10. An impact tool comprising a housing having a forwardly-extending nozzle with an opening at the front end thereof and communicating with a flywheel cavity therebehind, ram means mounted within the housing for sliding movement between a retracted position within the flywheel cavity and an extended position projecting into the nozzle, a substantially identical pair of flywheels journalled for rotation adjacent the ram means on opposite sides thereof about parallel axes normal to its direction of travel, drive means connected to the flywheels and operative to rotate the flywheels in opposite directions at substantially the same speed, pivotal mounting means journalling at least one of the flywheels for arcuate movement in a direction to change the spacing between

the pair of flywheels, the flywheels defining a clutch operative upon actuation to frictionally grip the ram means therebetween and propel same forwardly until it reaches a point where it is no longer in driving contact therewith, clutch actuating means connected to the mounting means and operative to actuate the clutch, clutch release means, associated with the mounting means, operative to reopen the space between the flywheels immediately upon their becoming drivingly disengaged from the ram means by deactuation of the clutch actuating means, and ram return means connected to the ram means and operative to return same to its retracted position following actuation thereof into extended position and actuation of the clutch release means.

11. A tool as claimed in claim 10 in which only one flywheel is mounted for said arcuate movement, and the rotational axis of the other of said flywheel is fixed, the arcuately-movable flywheel being pivotal rearwardly into its engaged position.

12. A tool as claimed in claim 10 or claim 11, comprising front stop means interposed in the path of the ram means and operative to limit the forward excursion thereof.

13. A tool as claimed in any one of claims 10 to 12, comprising rear stop means interposed in the path of the ram means and operative to stop same in retracted position.

14. A tool as claimed in any one of the claims 10 to 13, in which the clutch actuating means comprises a nosepiece on the forward end of the nozzle mounted for movement relative thereto between an extended and a retracted position, and link means interconnecting said nosepiece and mounting means, said link means being operative to engage the clutch upon movement of the nosepiece into its retracted position.

15. A tool as claimed in any one of claims 10 to 14 in which the clutch release means comprises a biasing member connected to normally urge the mounting means in a direction to disengage the clutch.

16. A tool as claimed in claim 10, in which one of the flywheels is mounted for rotation about a fixed axis, and the ram means is mounted for limited lateral movement to the extent necessary to place same in frictional engagement with the fixed flywheel.

17. A tool as claimed in any one of claims 10 to 16, in which means comprising a retractable stop is operatively associated with the clutch means for normally maintaining same in disengaged position, and a manually-actuated trigger means is connected to the retractable stop and is operative, upon actuation, to retract same and release the clutch means for movement into its engaged position.

18. A tool as claimed in any one of claims 10 to 17, in which the nozzle is provided with a second opening alongside the path of movement of the ram means and defining a breach sized to accept a member to be driven forwardly from the front end of the nozzle by the row means.

19. A tool as claimed in any one of claims 10 to 18, in which the drive means comprises ~~at least one electric motor,~~ and speed control means is electrically connected to said motor to vary the speed of flywheel rotation.

20. A tool as claimed in any one of claims 10 to 19, in which the length of the ram means is so related to the location of the clutch means that the ram means is moved forwardly into a position out of driving engagement with the clutch means before reaching the end of the nozzle.

21. A tool as claimed in claim 10, in which the drive means comprises a pair of electric motors connected to drive the flywheels independently of one another in opposite directions at substantially the same speed.

22. A tool as claimed in claim 10, in which only one of the flywheels is mounted for arcuate movement relative to the ram means and the other is journalled for rotation about a fixed axis, the contacting surfaces of the flywheels and ram means are shaped to make straight-line tangential contact with one another parallel to the spin axes of the flywheels, and in which the spin axis of the arcuately movable flywheel co-operates with the axis of pivotal movement of the mounting means to define a plane that intersects a second plane perpendicular to the direction of travel of the ram means at an acute angle whose tangent is equal to, or less than, the coefficient of friction between the contacting surfaces of the latter element and said arcuately-movable flywheel.

23. A tool as claimed in claim 11, in which the contacting surfaces of the ram means and flywheels make tangential contact with one another along lines parallel to the axes of rotation of the latter, and the axis of pivotal movement of the mounting means and the spin axis of the arcuately-movable flywheel journalled therein are so related to one another and to said line of tangential contact of said flywheel with the ram means when in driving engagement therewith that said spin axis stops ahead of the axis of pivotal movement.

24. A tool as claimed in claim 12, in which the front stop means comprises a cushioned abutment at the front end of the nozzle,

said abutment being effective to absorb and dissipate a substantial portion of any excess energy carried by the advancing ram means prior to its contacting a workpiece located in front of the nozzle.

25. A tool as claimed in claim 13, in which the rear stop means is so located as to stop the ram means in its retracted position such that the clutch means will initially engage the ram at the front end portion of the ram.

26. A tool as claimed in claim 23, in which the length of the ram means relative to the location of the clutch is such that the ram means is no longer in driving engagement with the clutch by the time the front end thereof reaches the front end of the nozzle.

27. A tool as claimed in claim 22, in which the tangent of the angle is less than the coefficient of friction.

28. A tool substantially as hereinbefore described with reference to the accompanying drawings.

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1487098 COMPLETE SPECIFICATION

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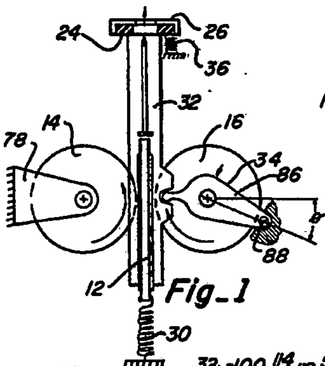
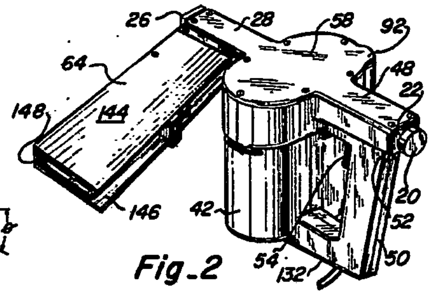


Fig_1



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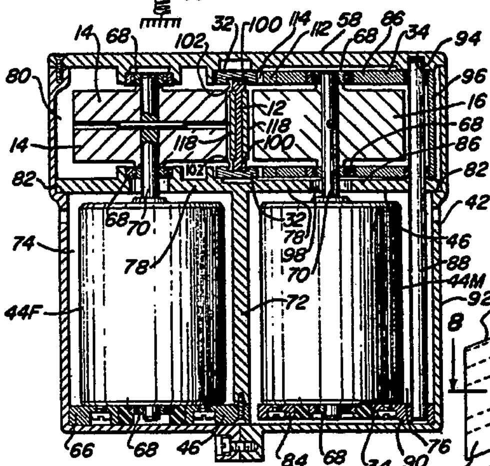

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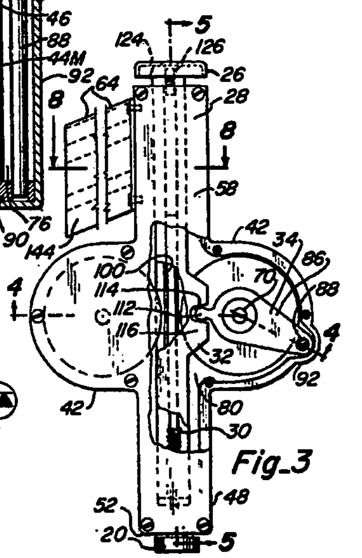

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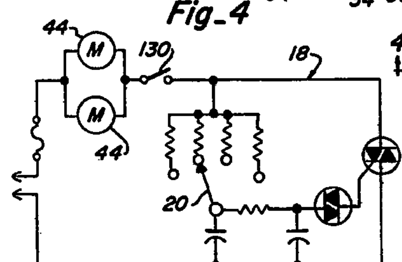

Fig_12 PRIOR ART

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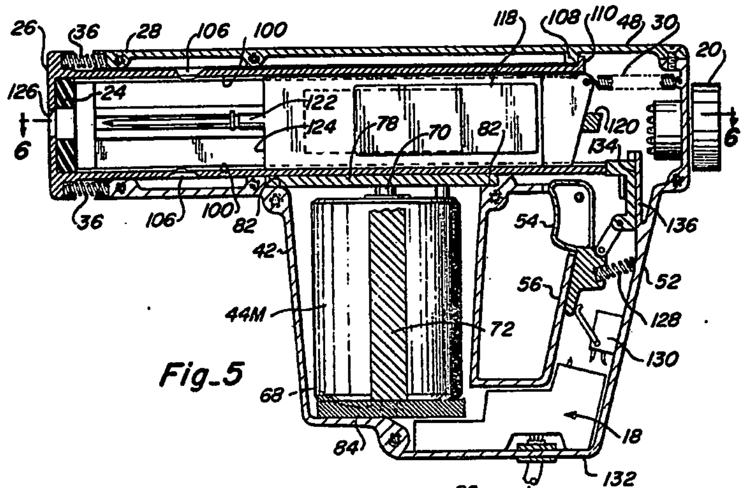

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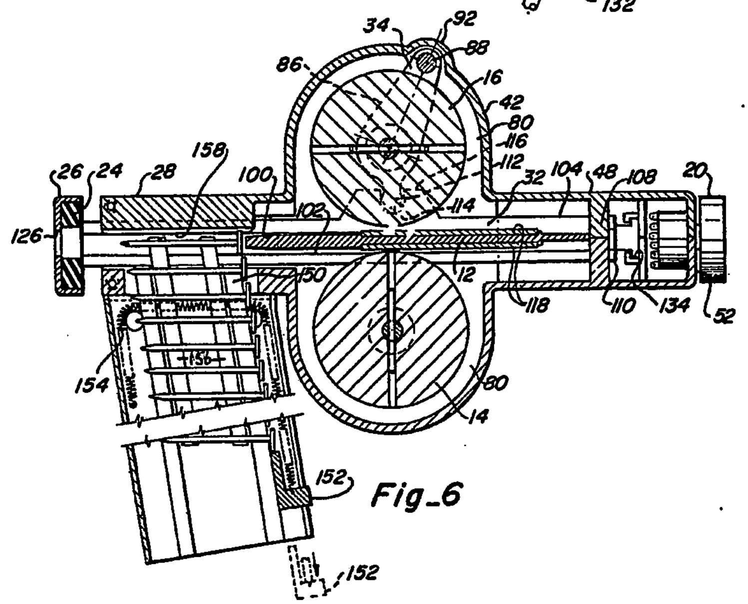

Fig_6

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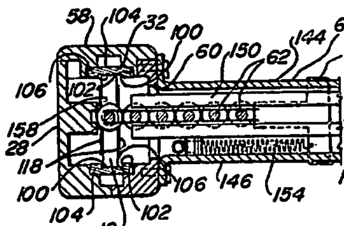
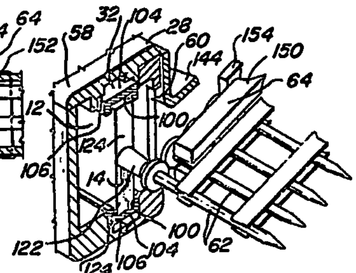


Fig.8



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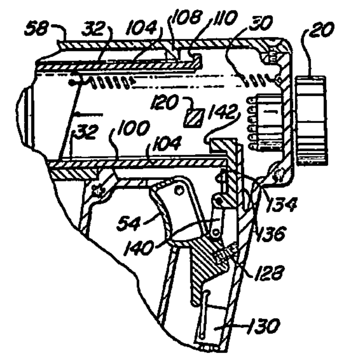

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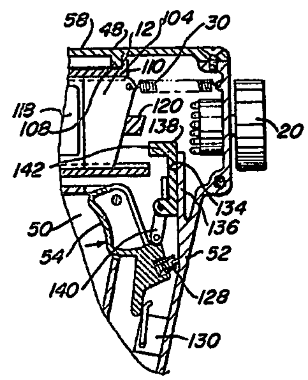

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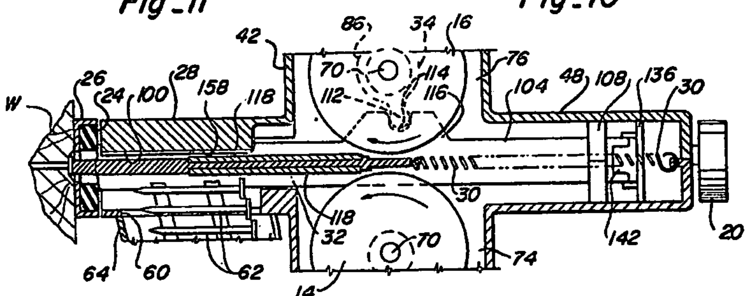

Fig.7